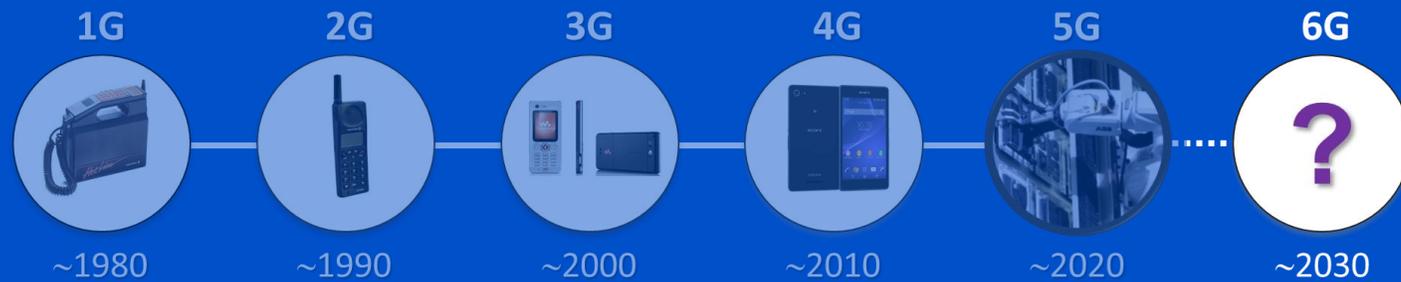




# 6G wireless connectivity

## Something new or more of the same?



Erik Dahlman

Ericsson

# Future wireless access – What do we need?



## What do we not need?

- Higher peak data rates
- Lower minimum latency?

## What do we need?

- Higher achievable data rates
- Higher network capacity
- Reliability, availability, resilience, ...
- Improved energy performance
- Lower cost
- ...

Especially for the uplink  
(uplink coverage)

# What is a “New Generation”?



## What characterizes a new generation?

- A big leap in technology?
- A big leap in capabilities?
- New spectrum?
- No need for backwards compatibility?
- New set of 3GPP specifications!

## A new generation gives a fresh start

- New features actually being implemented  
⇒ *More capable in practice*
- Possibility to remove features  
⇒ *Reduced complexity and cost*
- Restart of evolution cycle  
⇒ *Much more capable in the long run*

6G is critical to ensure the long-term evolution of wireless connectivity

# 6G wireless access



## Technology-wise 6G wireless access will inherit much from 5G

Keep  
aspects of 5G that work well

Change/update  
when motivated

Add  
functionality for new use cases

### Waveform, coding, and modulation

No major benefits seen from a radical change of waveform, coding, and modulation compared to 5G NR

- 3GPP should focus on areas with greater potential

### MIMO and multi-antenna features

6G MIMO will build on an evolved 5G MIMO framework

- Take learnings from 5G and avoid unnecessary/forced flexibility/complexity

Massive MIMO becoming even more massive

- Continue support for a significantly larger number of antenna elements
- Support for different architectures (e.g. fully digital hybrid and for flexible antenna design (e.g. low sidelobe array, multi-band antenna))
- Unified MIMO codebook for CSI reporting (e.g. avoid Type 1, Type 2, Type 3, ...)
- Make reciprocity (SSB) based CSI acquisition work in practice (address NR SRS implementation problems and foster/flexible SRS over wide BW)

Multi-TRP becoming interference-aware D-MIMO

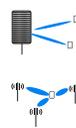
- Support more TRPs than in 5G
  - Increased network deployment flexibility, reduce signaling (e.g. OCL)
  - Location diversity (e.g. TRP, BS, user) to reduce SS-BW/SSB/SSB/SSB/SSB
  - Focus on DPS and C/I type solutions and target to maximize SINR instead of only SNR

Lean, dynamic and energy efficient based MIMO design

- Reduce reference signals and unnecessary transmissions, e.g. combine discontinuous with DM-RS based CSI measurement
- Dedicated CSI-RS measurement CSI reporting is seen as an "add-on" to PUSCH based CSI
- Natively support dynamic/adaptive reduction of number of active RF chains to reduce network energy consumption
- CSI-RS and CSI reporting (e.g. CSI-RS and CSI reporting) to be able to be reported with minimum user effort

UL MIMO

- Codebook based, non-coherent PUSCH
- Low-PAPR design (including DFT-s-OFDM for all PUSCH variants)



### Scheduling and control signaling

Processing timeline – avoid scheduling complications from 5G's multiple timelines

- Long CSI reporting time, in-order scheduling of PUSCH
- Scheduling CSI reporting before CSI measurement before transmission report to MAC/CFE



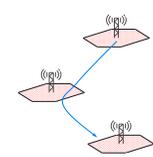
### Unified mobility

Unified measurement framework (merge RRM- and L1-CSI measurements)

- Configuration of reference signals (CSI-RS, SSB, ...)
- Configuration of report formats, conditions/triggers
- Measurement reports (see Unified Uplink Reporting)

Unified mobility mechanism

- Combine L3 + CHO + LTM into a single, unified mobility mechanism, i.e., ...
  - Different ways to switch the UE's set of reference signals (for sync, measurements, OCL)
  - Optionally, reset/reestablish protocols, trigger RA...



Discuss means to accelerate HO execution

- Keep critical parts of the UE configuration unchanged
- Indicating properties (tight sync of source and target; shared OCL properties, ...) if beneficial for the UE

Procedures, measurements and conditions ready for using mobility to provide resilience

Mobility measurements in idle and connected mode may use separate signals

- Example: S-SSB for idle mode and M-SSB for connected mode

### Integrated sensing

To enhance network performance and create new end-user services

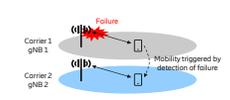
### Resilient communications

New business models and monetization opportunities based on service-level agreements require that CSPs assure high connectivity service availability. The necessary resiliency is realized by means of:

- Efficient and cost-effective redundancy to minimize the impact of failures
- Fast detection of failures and failover options

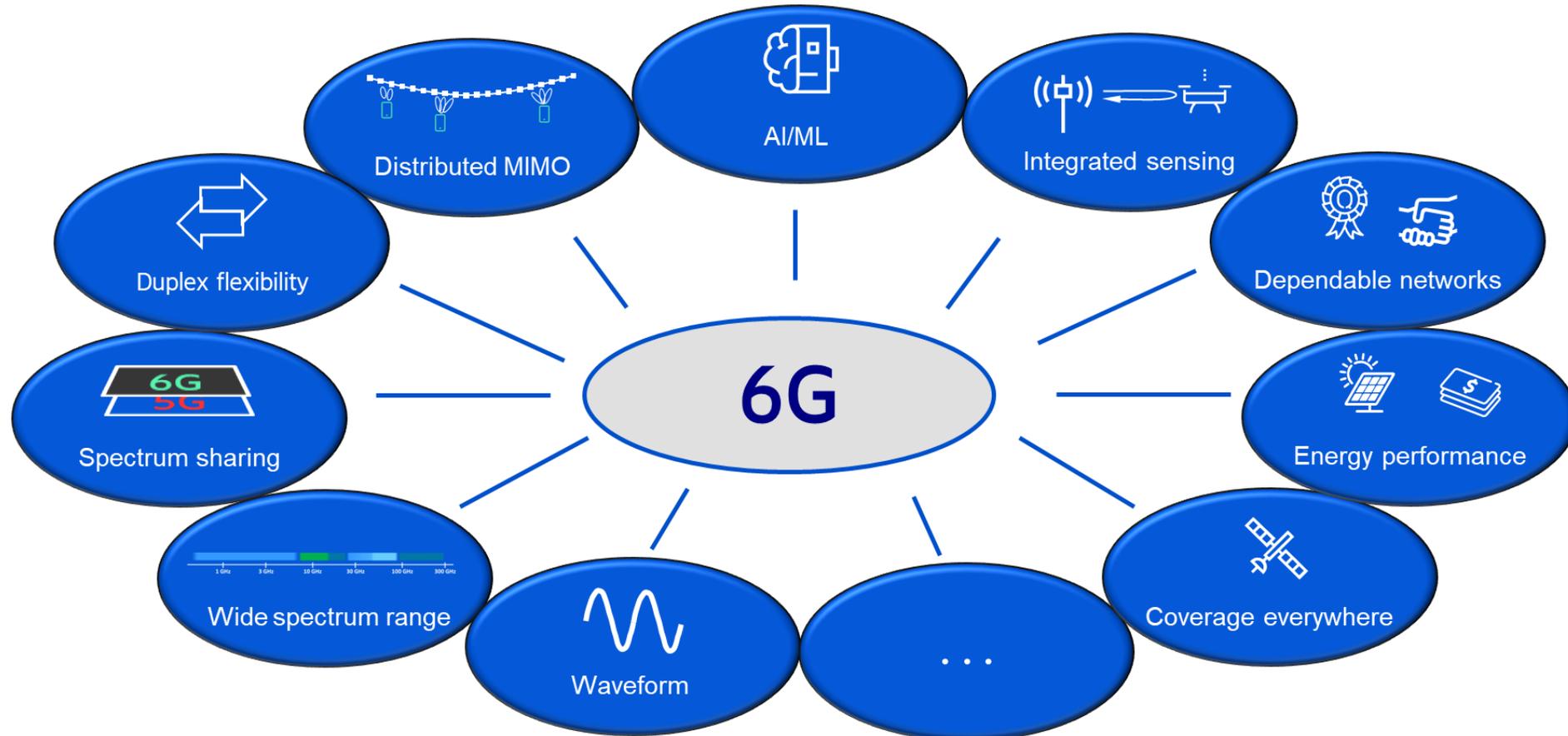
Resilient communications is enabled by 6G features for preventing and reducing service interruption time (e.g., due to link or functional failure):

- Improved **observability** including measurements and reports for failure detection, enabling proactive actions
- Robust **spectrum aggregation** providing alternative radio links (e.g., with minimal/no PCeU/SCell distinction; CA from non-collocated RUs)
- **Multi-TRP** for spatial redundancy
- **Mobility and RLM procedures** allowing for handing over UEs from a failing carrier to a well-functioning one



# 6G wireless access

## Some key technology components



# Spectrum for 6G

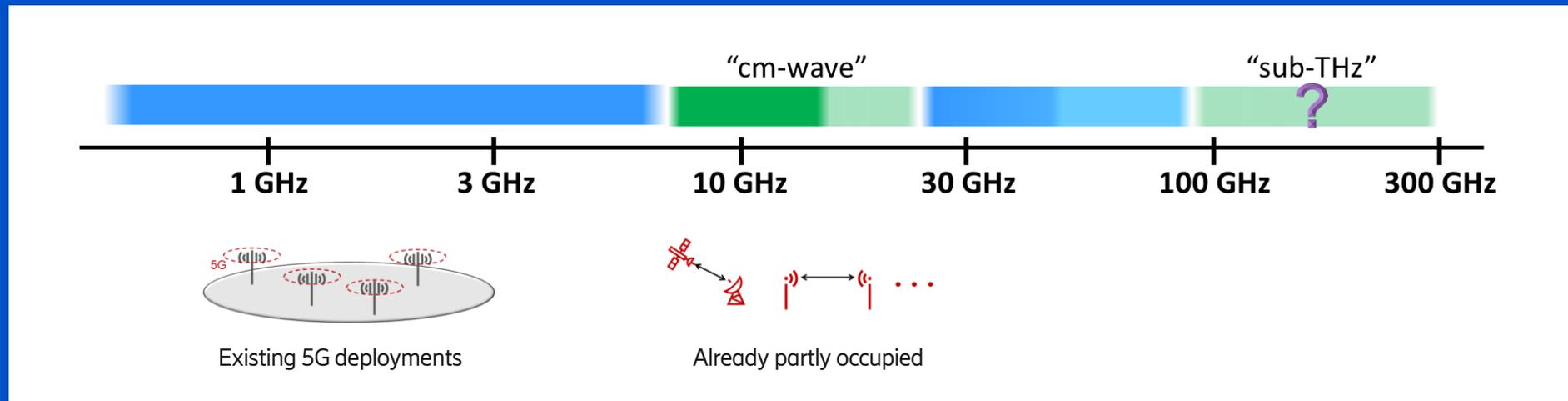


## Current 4G/5G spectrum

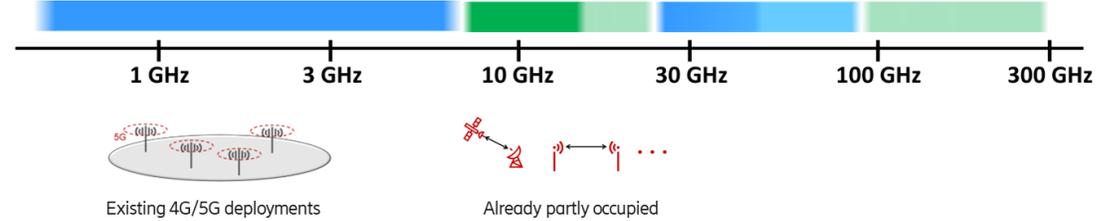
- Below 7 GHz
- mmw

## New 6G spectrum

- cm-wave
- Sub-THz?



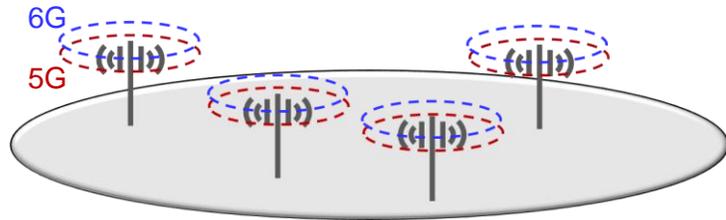
# Spectrum sharing



## 5G/6G spectrum sharing

Allow for 6G to be deployed on top of 5G

⇒ *Smooth introduction of 6G in existing spectrum*



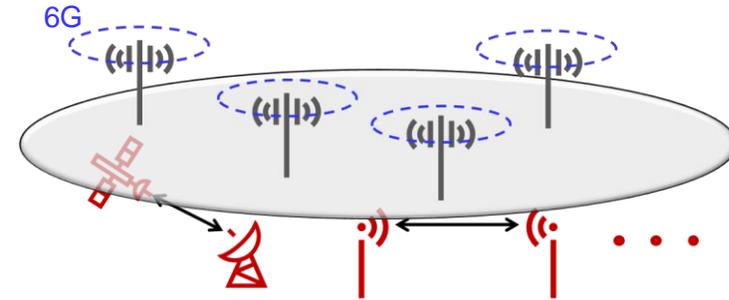
*Requires a 5G-compatible 6G waveform*

*Efficient spectrum sharing enabled by 5G "lean design"*

## Co-existence with other usages

Enable 6G deployment on top of other technologies

⇒ *Smooth access to new spectrum*

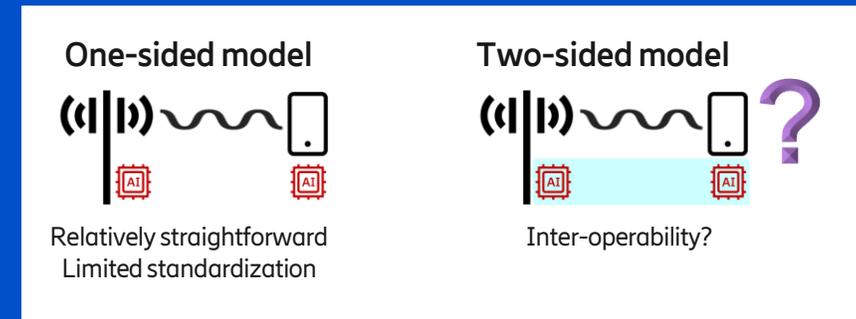
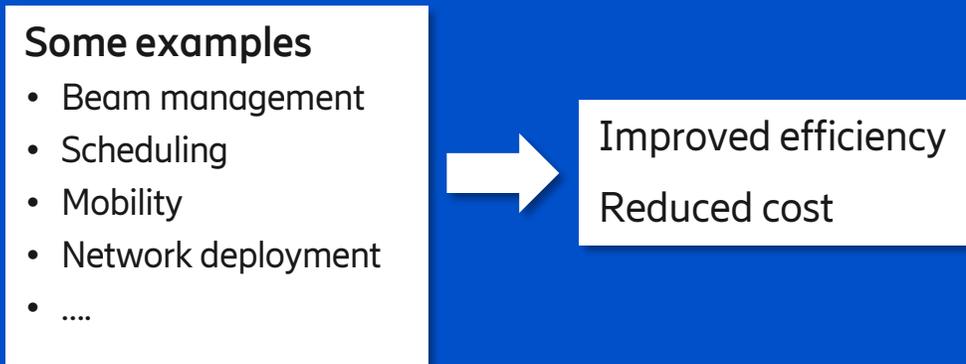


# AI for communication – where, when and how?



High-dimensional problems for which

- there is no good model
- deriving the “optimal” solution is difficult/impossible



Mainly implementation with limited specification impact

At least in the short/medium term

# Integrated communication and sensing a.k.a. "Situational awareness"



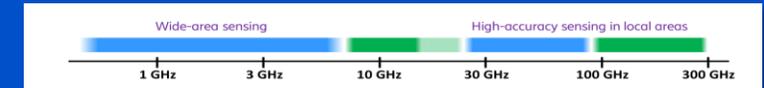
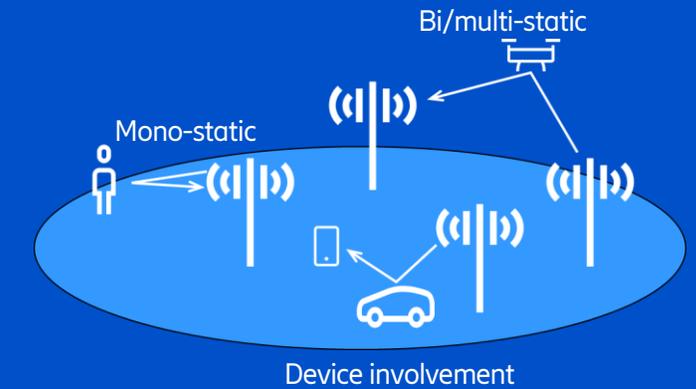
**Sensing:** Detect the presence/location/movement of passive objects

**ICAS:** Sensing as an integrated part of the communication network

- Reuse of communication resources (infra-structure, spectrum, devices) for sensing

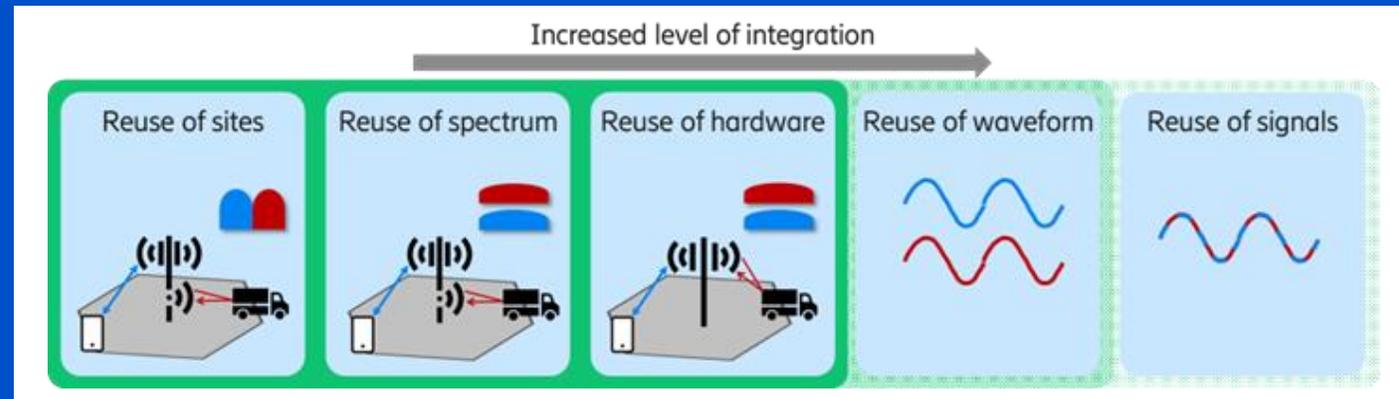


Introduction of sensing functionality with low incremental cost



Enable new/enhanced services

Enhance the network performance



# Mission-critical connectivity and dependable networks



A high-performance network that one can truly trust and depend on

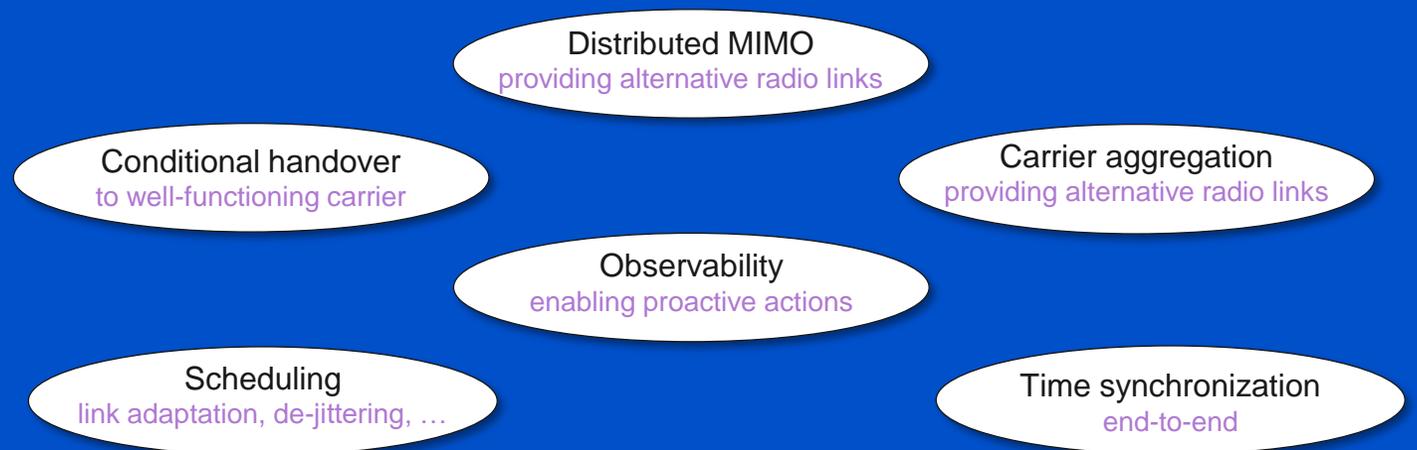
## Public networks

- Highly automated vehicles
- Professional video production
- Managed IT devices
- ...

## Dedicated networks

- Manufacturing
- Mining
- Oil and gas
- Connected workers
- ...

- High service availability from efficient and cost-effective redundancy to minimize the impact of failures
- Time-critical services, "the right packet at the right time"
- ...



# Summary



## 6G will inherit much from 5G

- Keep what is good!
- Update if motivated!
- Add if needed!

## 6G will further extend the capabilities of wireless access

- Dependable communication
- Situational awareness
- ...

6G is critical to ensure the long-term evolution of wireless connectivity

# Thank you!

